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14. ABSTRACT
This TOP describes procedures for determining the operational capabilities of muzzle-loaded mortar systems under a variety of environments

15. SUBJECT TERMS
Mortar Systems Muzzle-Loaded Mortars Prefiring Test Data Proof Firings Rate-of-Fire (Maximum/Sustained)

Maximum Operating Temperature Stability Versus Firing Surfaces

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure (TOP) 3-2-050 11 March 2010
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TESTING OF MORTAR SYSTEMS

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This TOP supersedes TOP 3-2-050, dated 2 April 1993.

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1. SCOPE.

This TOP describes procedures for determining the operational capabilities of only muzzle-loaded mortar systems in a variety of environments, the effects of transport on mortar components, and human factors and maintenance concerns. Mortar systems characteristics dependent upon ammunition type, such as rate-of-fire tests, are also considered. Background information is presented in Appendix A.

Ammunition-specific tests, such as cook-off and blast overpressure and noise, have been eliminated from this document as they are better addressed under safety testing of mortar ammunition (TOP 4-2-504(3))[1**].

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Firing range	Selected to suit test requirements and to provide adequate protection for personnel and equipment in event of ammunition and/or weapon failure.
Temperature conditioning chamber	To condition items to temperatures from 71 to -51 $\pm$ 2 ^{o}C, with relative humidities ranging from 5 to 95 percent.
Environmental chambers	To maintain environments as required for adverse conditions testing.
Nondestructive test (NDT) facilities (magnetic particle, X-ray)	To detect and evaluate surface or subsurface discontinuities (i.e., material soundness).
Vibration test facility (guidance in International Test Operations Procedure (ITOP) 1-2-601[2])	As required.
Rough-handling facilities (guidance in ITOP 4-2-602[3])	As required.
Test Courses	As required.

** Superscript numbers correspond to references in Appendix C, References.

2.2 Instrumentation.

Devices for Measuring	Permissible Measurement Uncertainty
Projectile muzzle velocities (guidance in ITOP 4-2-805[4])	±0.1 percent or ±0.5 m/s (whichever is higher).
Weapon chamber pressure (guidance in ITOP 3-2-810[5])	±2 percent.
Time of interior ballistic event (guidance in ITOP 3-2-810)	±3 percent.
Test item temperature (guidance in TOP 1-1-058[6])	As required.
Physical characteristics of test item (guidance in TOP 3-2-801[7], ITOP 3-2-803[8])	As required.
Meteorological conditions (guidance in TOP 3-1-003[9])	As required.
Test events (e.g., video tape, 35-mm camera)	As required.

3. REQUIRED TEST CONDITIONS.

3.1 Test Planning.

a. The tests as described in this TOP are used to determine safety, performance, and reliability characteristics of the weapon system in question. Plan the order of testing to allow the safety evaluation tests (paragraph 4.2.1) to be conducted first. Conduct high-risk tests which will reveal design weaknesses immediately following the safety tests.

b. Take care in planning the test sequence. Two or more subtests may be combined so long as no test criteria or objectives are jeopardized. Certain tests may be done concurrently, while other tests (such as sustained rate-of-fire and maximum operating temperature tests) can be done sequentially to take advantage of existing mortar temperatures to eliminate the need for expending additional rounds or using barrel heaters to raise the operating temperature of the mortar. Use inert projectiles and ammunition during firing tests if the use of such ammunition will not compromise test results.

c. The test procedures described herein may be required in a Detailed Test Plan (DTP). The procedures may require modification for unique items or materials or to satisfy specific testing requirements as stated in the customer/materiel developer's test plan or the evaluator’s System Evaluation Plan (SEP).

3.2 Test Preparation.

3.2.1 Extreme Temperature Limits.

a. Unless otherwise specified, conduct mortar-system tests at a lower-extreme-temperature of -46 °C, which corresponds to the cold category C2 of North Atlantic Treaty Organization (NATO) STANAG 4370[10] and MIL-STD-810G[11].

b. Conduct upper extreme temperature tests at 63 °C corresponding to the basic hot climatic category A2 of NATO STANAG 4370 and MIL-STD-810G.

c. Condition ammunition to be fired at either the upper or lower temperature extreme for a minimum of 24 hours.

3.2.2 Weapon Instrumentation.

Measure chamber pressure through the use of external piezoelectric or copper-crusher gauges. The use of such gauges requires a mortar cannon/barrel/tube tapped to receive the gauges. If such a tube cannot be obtained, use other methods, such as strain gages or internal copper-crusher gauges to measure chamber pressure. Refer to ITOP 3-2-810.

Note:When employing external crusher gauges, it is important not to replace used gauges with new gauges until immediately before the next round is to be fired. Residual heat from the mortar may degrade the yield strength of the copper or aluminum gages and thus skew the pressure readings recorded.

3.2.3 Arrival Inspection.

a. Visually inspect the equipment/components for signs of abnormal conditions: wear, rust, interference, and bright surfaces.

b. Note special tools, accessories and protective covers supplied.

c. Conduct appropriate (for component material) inspection on the mortar cannon/barrel, basecap, and mount as described in TOP 3-2-807[12], or in accordance with customer/materiel developer provisions.

d. Record the following:

(1) Test weapon type, model and serial number.

(2) Type of cannon/barrel.

(3) Type of firing mechanism.

(4) Type of sight unit.

(5) Description of all accessories and tools supplied.

(6) Description of the physical condition of all mortar components, including faults detected by NDT techniques and handwheel effort to operate elevation, cross-level (if apropos) and traverse mechanisms throughout the entire range of movement.

(7) Presence of rust, burrs, abnormal wear, points of interference, and bright, reflective surfaces.

(8) Adequacy of any covers supplied to protect the equipment from the environment.

(9) Cannon bore diameter data as described in TOP 3-2-801.

(10) Cannon/barrel borescope/visual inspection results as described in ITOP 3-2-803.

(11) Length of firing pin protrusion.

3.2.4 Physical Characteristics.

a. Determine the total weight of the test item and mount components.

b. Prepare the item for hand carrying as described in the appropriate Field or Technical Manual and note the number, weights and description of loads into which the mortar unit can be disassembled.

c. Prepare the item for transport on either a towed cart or as part of a mortar carrier, and note the weight at each wheel, total weight, lunette reaction at pintle height, and height of lunette when reaction is zero.

d. Prepare the item for firing as described in the appropriate Field Manual.

e. Photograph the test item as described in paragraphs 3.2.4b through 3.2.4d above, paying particular attention to any unusual design features.

f. Determine types of rounds to be fired from mortar during test and all other compatible munitions.

3.2.5 Characteristic Data Sheet.

Prepare a Characteristics Data Sheet in accordance with TOP 3-2-500[13] consisting of a general-view photograph of the weapon and a listing of principal physical and performance characteristics.

4. TEST PROCEDURES.

4.1 Prefire Functioning and Alignment Tests.

Determine the smoothness of operation, compatibility/interoperability of all new system components or proposed and in-service component combinations as follows.

4.1.1 Mortar Cannon/Barrel.

4.1.1.1 Method.

a. Visually examine the interior condition of the cannon/barrel and, when applicable, the threads on the breech end of the barrel.

b. Determine the ease of alignment, assembly and disassembly of the individual mortar-tube sections where applicable.

c. Determine the need for quadrant seats on the tube or on the clamp.

4.1.1.2 Data required.

a. Interior condition of tube.

b. Ease of alignment, assembly and disassembly of tube sections.

c. Need for quadrant seats on the tube or the clamp.

4.1.2 Basecap - Fixed Firing Pin.

4.1.2.1 Method.

a. Remove the basecap from the tube.

b. Perform required measurements such as firing pin protrusion.

c. Replace basecap onto tube.

4.1.2.2 Data required.

a. Ease of disassembly of the basecap from the tube when not permanently attached.

b. Ease of replacement of firing pin.

c. Length of firing pin protrusion.

d. Concentricity of firing pin hole and basecap tube threads, if not provided by the developer.

e. Ease of basecap assembly.

f. Conformance of component axes to specifications unless stipulated by the developer.

4.1.3 Basecap - Selectable Firing Mechanism.

4.1.3.1 Method.

a. Remove basecap from tube.

b. Operate firing safety switch/mechanism (and trigger, if applicable). Measure firing pin protrusion in drop fire mode; switch to safe mode and back to fire mode, put hand pressure on firing pin and then remeasure protrusion.

c. Disassemble and reassemble firing mechanism and repeat step in paragraph 4.1.3.1b.

4.1.3.2 Data required.

a. Method of functioning.

b. Ease of selecting the different types of firing.

c. Interference between the fire/safe switch or trigger mechanism and the breech cap or baseplate when tube is at approximately 45^{o} elevation.

d. Ease of assembly and disassembly.

e. Smoothness of operation.

f. Conformance to specifications if required by developer/evaluator.

4.1.4 Shock Absorbers.

4.1.4.1 Method.

Note:If the mortar has a recoil system, obtain the characteristics of the recoil portion of the mount as described in the applicable sections of ITOP 3-2-815[14].

a. Manually exercise shock mechanism.

b. If required by developer or evaluator, disassemble shock absorber mechanism, inspect components and reassemble.

4.1.4.2 Data required.

a. Ease of assembly and disassembly of shock absorber mechanism.

b. Types and adequacy of lubricants.

c. Adequacy of moisture-proofing.

d. Adequacy of operation.

Note:Manually pull the shock absorber out of battery and allow it to return to in-battery position. If it fails to return or returns very slowly, check the alignment of the moving parts with their housing and verify the adequacy of provisions for the escape of trapped air.

4.1.5 Elevating and Traversing Mechanisms.

4.1.5.1 Method.

a. Elevate and traverse weapon through the entire range of movement using both coarse and fine adjustments.

b. Disassemble and reassemble both mechanisms if a crew, or direct support function.

4.1.5.2 Data required.

a. Ease of assembly and disassembly.

b. Smoothness of gear operation throughout movement range in both elevation and traverse. Note/report positions/areas of increased or decreased resistance to movement.

c. Amount of gear backlash in both elevation and traverse.

d. Number of handwheel turns per degree of movement in elevation and in traverse.

e. Movement limits:

(1) Total distance of elevation adjustment.

(2) Total traverse distance.

f. Safety hazards and inconveniences caused by handwheel location, taking into account the possibility of interference between the operator's hand and the tube support of the traverse yoke.

4.1.6 Mortar Clamp.

4.1.6.1 Method.

a. Unlock clamp and remove tube from constraint.

b. Reclamp tube.

4.1.6.2 Data required.

a. Ease of fastening and locking the clamp to the mortar.

b. Clamp slippage.

4.1.7 Cross-Leveling Mechanism.

4.1.7.1 Method.

a. A cross-leveling mechanism may be provided to remove induced cant from weapon.

b. Operate the mechanism through the entire range of movement two or three times.

4.1.7.2 Data required.

a. Smoothness of operation using the coarse and fine adjustments of the cross-leveling mechanism.

b. Ease of operation, determined while observing the level vial in the traverse yoke and checking the freedom of movement of the leveling mechanism when in the unclamped position.

c. Locking ability of clamp(s).

4.1.8 Telescopicallv-Adjusted Bipod Legs (if applicable).

4.1.8.1 Method. Adjust legs to minimum (storage or travel position) and maximum length.

4.1.8.2 Data required.

a. Freedom of movement.

b. Locking ability of clamps.

4.1.9 Bridge and Standard (if applicable).

4.1.9.1 Method.

a. Without moving the elevating and traversing mechanisms, shake tube and exercise recoil system.

b. Elevate and traverse mortar through range of movement.

4.1.9.2 Data required.

a. Fit of lugs with the trunnions in the bridge.

b. Ability of tube to return to original position after being temporarily displaced.

c. Operation of traversing and elevating mechanisms in the standard.

4.1.10 Baseplate.

4.1.10.1 Method.

a. Assemble baseplate if not one-piece.

b. Insert tube into baseplate and elevate, depress and rotate tube, checking for ease of movement, looseness of fit or interference between basecap and trigger mechanism or baseplate.

c. Check for interference with basecap at minimum elevation.

d. Check for basecap interference during assembly/disassembly and misfire procedures.

4.1.10.2 Data required.

a. Fit of ball on mortar basecap into baseplate socket.

b. Ease of assembly and disassembly, if applicable.

c. Method of locking baseplate latches, if applicable.

d. Adequacy of carrying handles, if provided.

4.1.11 Sighting Equipment.

4.1.11.1 Method.

a. Affix sight unit (and/or boresight) to mortar.

b. Use sighting equipment to lay-in mortar.

4.1.11.2 Data required.

a. Ease of operation of sighting equipment.

b. Accuracy of sight-alignment (i.e., deviation from an established azimuth, compared with surveyor's transit) throughout range of movement.

c. Ease of alignment to the line of sight, checked with a mortar boresight.

d. Vial(s) adjustment ease.

e. Damage susceptibility.

f. Adequacy of the provision for stowing and carrying sighting equipment.

g. Adequacy of tools.

h. Adequacy of instructions.

i. Interference of sight controls with mount parts.

4.1.12 Mortar (Assembled).

4.1.12.1 Method.

a. Assemble/disassemble or move the test item from the traveling position to the firing position and back to the traveling position; record data in accordance with paragraph 4.1.12.2 below. This task should be repeated three times with different test personnel.

b. Mark components subject to severe strain with trammel points or straightness lines.

c. Mount strain gages cover the surface of areas subject to strain with brittle lacquer as described in TOP 3-2-809[15].

4.1.12.2 Data required.

a. Time required to prepare weapon for firing.

b. Time required to prepare weapon for travel.

c. Difficulties encountered in preparation for firing and travel.

d. Number of personnel required to prepare the weapon for firing and travel.

e. Adequacy of manuals and/or operating instructions.

f. Adequacy of supplied tools.

g. Need for system-unique tools or whether common, off-the-shelf tools are adequate.

4.2 Firing (Ambient Temperature) Tests.

Notes: Use inert-loaded projectiles and inert fuzes during the firing tests when the substitution will allow the test objectives to be accomplished. Have firing crew practice misfire procedures (paragraph 4.2.5) before proof firing and any other firing test.

4.2.1 Safety Evaluation Test.

The safety evaluation of any completely new system or any new cannon/barrel, basecap, baseplate, bipod or blast attenuation device design or modification requires the following tests to be conducted.

a. Proof firing of the weapon as described in paragraph 4.2.2. This test shall be conducted on all test systems before any other firing tests.

b. Demonstrate the system's maximum rate-of-fire (paragraph 4.2.3.2) and the required sustained rate-of-fire, (paragraph 4.2.3.3) associated with the designated/design maximum operating temperature (D-MOT).

c. Verification of weapon-system operational capability at maximum operating temperature as described in paragraph 4.2.4.

4.2.2 Proof-Firing Test.

4.2.2.1 Method.

Notes:Proof-fire any mortar system component to be fired for test purposes to disclose any deficiency or malfunction that would preclude its further use. Under no circumstances shall it be used with personnel exposed until after proofing has been completed. Perform proof-firing tests at prevailing ambient temperatures with the types and number of rounds specified in the Materiel Developer's Test Plan, Acceptance Test Procedure or Quality Assurance Provisions. If a firing schedule was not provided, fire the rounds, in sequence, at the positions of elevation and traverse shown in Table 1.

TABLE 1. PROOF FIRING SCHEDULE

No. of Rounds	Propelling Charge[a]	Elevation, deg	Traverse
Seating rounds (approximately 5)	As required	60	Center
1	Charge 3	60	Center
1	Charge 4	45	Maximum right
1	Proof	45	Center
1	Charge 4	45	Maximum left
1	Proof	60	Center

[a]Charge levels above are based on a four-increment propelling charge system.

4.2.2.2 Data required.

a. Type and condition of soil under the baseplate in terms of moisture content and Cone-Penetrometer Index using a cone penetrometer in conjunction with a soil sampler and remolding test equipment as described in Technical Bulletin (TB) ENG 37 Soils Trafficability[16]. These data should be recorded at the firing site on each day of proof firing as well as for each day of stability and baseplate seating (paragraph 4.2.7) tests.

b. Number of rounds required to seat the baseplate.

c. For each round fired after the baseplate has been seated

(1) Chamber pressure as described in ITOP 3-2-810.

(2) Muzzle velocities as described in ITOP 4-2-805.

(3) Length of out-of-battery movement of shock absorber.

(4) Change in elevation and traverse of mortar.

d. Incurred strain as described in TOP 3-2-809.

e. During and at completion of proof firing, inspect for evidence of the following as applicable:

(1) Breaks, cracks (note welded portions), deformations, and binding of working parts of the mortar and mount, photographing any failures.

(2) Interference between the operating parts at all possible positions of elevation and traverse.

(3) Ability of shock absorbers to return to the in-battery position at various positions of the collar and tube support.

(4) Gas leakage at juncture of mortar tubes and basecap.

(5) Gas leakage between firing pin and its contact surface in the basecap.

(6) Gas leakage at juncture of sectional tubes.

(7) Slippage of mount collar on the mortar tube.

(8) Slippage or turning of bipod legs or standard after baseplate seating.

(9) Slippage of leveling mechanism.

(10) Ease of loading.

(11) Completeness of propellant burn within mortar tube.

(12) Ability of on-carriage fire-control equipment to remain locked in position during firing and to retain boresight alignment.

(13) Malfunctioning of ammunition (misfires and hangfires).

(14) Unusual occurrences affecting crew safety.

4.2.2.3 Post Proof-Firing Inspection.

4.2.2.3.1 Method.

Upon completion of the proof firing, perform the following:

a. Elevate, cross-level and traverse the weapon through its complete range of movement, recording handwheel effort at several intervals and at any portion of movement range where effort is appreciably different.

b. Compare trammel-point positions on the mount with original positions.

c. Measure firing-pin protrusion and note any deformation.

d. Examine all moving parts and note evidence of wear or damage.

e. Record, compare bore diameter data. Report any significant changes.

f. Visually inspect the bore interior.

g. Remove strain gages, if applicable.

h. Use appropriate (for metallic or non-metallic tube material or tube condition) NDT technique to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.2.2.3.2 Data required.

a. Bore diameter data.

b. Bore inspection comments/data.

c. Effort required to turn elevation, cross-level and traverse handwheels.

d. Change in trammel-point positions relative to original position.

e. Firing-pin protrusion measurements.

f. Evidence of wear or scoring.

4.2.3 Rate-of-Fire Tests.

Notes: (1) Maximum rate-of-fire is described as the maximum rate at which it is physically possible for a trained gunner to continually fire the weapon; limited by barrel elevation and/or temperature (D-MOT) constraints. (2) Sustained rate-of-fire is defined as the rate-of-fire, for a particular charge and ammunition type, at which the test weapon can be continuously fired without exceeding the barrel's D-MOT.

4.2.3.1 Test Preparation.

a. Adapt and install an electric timer to measure the time required for a projectile to slide down the tube and strike the bottom for tube elevations of 45, 60 and 85^{o}.

b. Affix thermocouples to points along the tube where maximum temperatures may be expected (ignition zone, middle of clamp, near muzzle), or as directed in the test plan.

Note: Affix thermocouples to the tube so as not to alter the physical properties of the tube.

c. Place the test item on soil similar to the soil on which the proof firing was conducted and fire a minimum of five rounds to seat the test item.

4.2.3.2 Maximum rate-of-fire test.

4.2.3.2.1 Method.

a. Record ambient temperature 15 minutes prior to start of test at all locations on tube before firing commences.

b. Have one member of the test team fire the weapon at specific elevation(s) and charge(s) specified by the system integrated product team - Integrated Product Team (IPT) as fast as possible for the specified time period OR until the tube temperature reaches the D-MOT.

c. Record data as indicated in paragraph 4.2.3.2.2 below.

d. Repeat this procedure a minimum of two times at each elevation and/or charge, using different personnel for each repetition.

e. Use appropriate (for metallic or non-metallic tube material or tube condition) NDT technique to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.2.3.2.2 Data required.

a. Time of descent of the cartridge at each specified tube elevation.

b. For each team member at each specified elevation:

(1) Time between each round fired.

(2) Number of rounds fired to reach D-MOT.

(3) Time to reach D-MOT.

(4) Maximum rate-of-fire (number of rounds fired/minute, for time to reach D-MOT). Expressed as number of rounds per minute for X minutes.

(5) Video recording of loader movements and effect of blast, smoke, and flash on visibility, operation of fire-control equipment, and on firing team members.

4.2.3.3 Sustained rate-of-fire test.

Note:Unless this test can be performed immediately after the maximum rate-of-fire test, install “heat tape” around the barrel in a helical configuration with a quick-release mechanism near the top to allow rapid removal with minimal manual manipulation.

4.2.3.3.1 Method.

a. Record temperature at all specified locations throughout this test.

b. If necessary, heat the mortar cannon/tube with heat tape until a temperature approximately 30 °C below the D-MOT is reached. Immediately following this phase, quickly remove the heat tape and rapidly fire as many maximum service charge rounds as is necessary to raise the tube temperature close to the D-MOT.

c. Alter the rate-of-fire (using one of the charge levels specified by the system IPT) so that the tube temperature does not greatly exceed D-MOT and is held constant near the D-MOT.

d. Record the rate-of-fire at which the tube temperature is stabilized at the D-MOT.

e. Repeat steps in paragraphs 4.2.3.3.1a through 4.2.3.3.1d for any other charge levels specified by the system IPT or user requirement.

f. Use appropriate (for metallic or non-metallic tube material or tube condition) NDT technique to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.2.3.3.2 Data required.

a. Temperature of mortar tube at all specified, instrumented locations.

b. Sustained rate of fire for all applicable charge levels.

c. Report on results of NDT.

4.2.4 Maximum Operating-Temperature Test.

Note:The purpose of this test is to determine whether rapid firing of numerous (200) maximum service charge rounds at D-MOT degrades the structural integrity of the system. It can be done immediately following the sustained rate-of-fire test or the maximum rate-of-fire test.

4.2.4.1 Method.

a. If necessary, heat the mortar tube with “heat tape” until a temperature approximately 30 °C below the D-MOT is reached. Immediately remove the heat tape and rapidly fire as many maximum service charge rounds as is necessary to bring the tube temperature to the D-MOT.

b. When the maximum operating temperature (D-MOT) is reached, immediately fire 200 maximum service charge rounds (conditioned at 63 °C for 24 hr) at a rate which maintains the tube temperature at the D-MOT.

c. Note the time at which each round is fired.

d. After all firing has been completed, visually inspect the mortar system.

e. When the system has returned to ambient temperature, measure the bore diameter and record operability of all mechanisms; note effort to turn handwheels.

f. Use appropriate (for metallic or non-metallic tube material or tube condition) NDT technique to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.2.4.2 Data required.

a. Tube temperature throughout firing and for 15 minutes following firing.

b. Time at which each round was fired.

c. Weapon-bore dimensions and borescope reports before and after firing.

d. Operability of all mechanisms, and the effort required to turn the handwheels.

e. Material soundness test results (TOP 3-2-807) before and after firing.

f. Report on results of NDT.

4.2.5 Misfire Removal Test.

4.2.5.1 Method.

To determine whether additional safety procedures are necessary in removing misfires from the test mortar, have required gun crew members help to remove a simulated (inert warhead and propelling charge) misfire from the test mortar using the Test Center's Standing Operating Procedures (SOPs) misfire procedures and Army Field Manual or the mortar system Operator's Manual. Accomplish the misfire removal while operating within safety regulations. Rotate positions of crew members until each has served in every position.

4.2.5.2 Data required.

a. Ease and safety of round removal.

b. Recommendations for modifying removal technique, if appropriate.

c. Compare/crosswalk SOP, Operator's Manual and Field Manual procedures or provide refined procedures to IPT/Combat Developer for coordination/ consideration. Report discrepancies and recommended changes to respective document proponents.

4.2.6 Pressure-Versus-Time Tests.

4.2.6.1 Method.

a. Unless pressure-time and pressure-travel data have been generated by the Developer using a ballistic tube, modify a test mortar with pressure taps to receive appropriate pressure transducers in accordance with ITOP 3-2-810. Otherwise, attach strain gages, at locations deemed necessary, along the entire length of the tube.

b. Temperature condition rounds for a minimum of 24 hours as indicated in Table 2 and fire immediately.

TABLE 2. CHARGES AMD TEMPERATURES FOR PRESSURE-VERSUS-TIME TEST ROUNDS

No. of Rounds	Propelling Charge Level[a]	Temperature, ^{o}C
3	Charge 0	21, -46
3	Charge 1	21
3	Charge 2	21
3	Charge 3	21
3	Charge 4	21, 63
3	Proof	21

[a]Charge levels above are based on a four-increment propelling charge system.

4.2.6.2 Data required.

a. As-fired cartridge weights.

b. Muzzle velocities.

c. Peak chamber pressure.

d. Pressure versus time and pressure versus travel traces.

e. Temperature of conditioned ammunition.

4.2.7 Stability-Firing and Seating Tests.

4.2.7.1 Method.

Determine the stability of the mortar and baseplate and the ease of seating in both prepared and unprepared positions, as follows. Video-tape all firings for later review.

Note:If possible, repeat a stability phase for each set (with/without relaying after each round fired; Using prepared/unprepared position) of test conditions; i.e., on the same day, repeat the firing of a test item from nearby ground of similar appearance. This repetition provides data for estimating the variation in stability that can be expected from the same baseplate under similar conditions. The magnitude of this variation is a good criterion for determining whether observed stability differences in baseplates are caused by differences in design or by the unavoidable variation in soil conditions.

a. Select a firing site with fairly compacted soil and determine and record the type of soil upon which the weapon is positioned as described in paragraph 4.2.2.2a.

b. After preparing firing position in accordance with the Field Manual, and with sandbags appropriately positioned on the baseplate, conduct the firing as shown in Table 3, RELAYING THE MORTAR AFTER EACH SINGLE ROUND and each group firing.

TABLE 3. STABILITY FIRING SCHEDULE

No. of Rounds	Elevation, deg	Traverse
Seating rounds (approximate 5)	60	Center
Two individual rounds and one five-round group at each elevation/traverse combination shown below.	Maximum	Center
	Maximum	Maximum left
	Maximum	Maximum right
	60	Center
	60	Maximum left
	60	Maximum right
	Minimum	Center
	Minimum	Maximum left
	Minimum	Maximum right

Note: All rounds are fired at maximum service charge.

c. Record data as directed in paragraph 4.2.7.2g below.

d. Repeat above firings without using sandbags and without relaying the weapon after each round.

e. Repeat steps in paragraphs 4.2.7.1a through 4.2.7.1d with the weapon on:

(1) Sand or much softer (less compacted) soil than the first surface.

(2) Mud - soil with a much higher moisture content than the first surface.

(3) Very hard ground (e.g., crusher run or clay).

f. Repeat all steps with weapon in unprepared positions.

4.2.7.2 Data required.

a. Measurements of each type of soil as described in paragraph 4.2.2.2a.

b. Comments on baseplate seating adequacy on unprepared soil.

c. The necessity for field expedients.

d. Preparations made to the positions.

e. Number of rounds required for each seating.

f. Comments as to the ease or difficulty experienced in seating the weapon.

g. After the baseplate is firmly seated, record the following for each round or group of rounds fired.

(1) Change in elevation and deflection.

(2) Number of centimeters the baseplate:

(a) Moved downward.

(b) Moved to the rear.

(c) Tilted side-to-side and front-to-rear.

4.2.8 Hard Surface-Firing Tests.

4.2.8.1 Method.

Note:This test gives an indication of how the baseplate of the system may perform when fired from ice and snow surfaces.

a. Position the test weapon on ice, solidly frozen ground or a macadam surface without field expedients and conduct the firing as shown in Table 4. Record the firings on video and provide a detailed description of the type of surface used.

TABLE 4. HARD SURFACE FIRING SEQUENCE

No. of Rounds	Elevation, deg	Traverse
Seating rounds (approximate 5)	60	Center
5	Maximum	Maximum left
5	Maximum	Maximum right
5	60	Maximum left
5	60	Maximum right
5	Minimum	Maximum left
5	Minimum	Maximum right
5	Minimum	Center

Note: All rounds are fired at maximum service charge.

b. Examine the mortar after each round and record data as directed in paragraph 4.2.8.2 below.

c. Photograph or film any defects or hazardous occurrences.

d. Repeat steps in paragraphs 4.2.8.1a through 4.2.8.1c using field expedients.

e. Repeat steps in paragraphs 4.2.8.1a through 4.2.8.1d with the weapon on a rocky surface.

4.2.8.2 Data required.

a. Location of any breaks, cracks, etc.

b. Component failures.

c. Ability of mortar to seat and remain seated.

d. Incidents that may affect crew safety.

4.2.9 Accuracy Firings.

4.2.9.1 Method.

Notes: Weapon accuracy or system accuracy can be determined. Determine weapon accuracy by use of the gunner's quadrant for elevation and the surveyor's transit for azimuth; determine system accuracy by using the system sight unit for mortar laying. Standard ammunition should be used for this test. If developmental ammunition is used, its contribution to system error will be unknown unless groups from several lots are fired. The U.S. Army Armament Research, Development and Engineering Center (ARDEC) Firing Tables Branch should specify details of accuracy firings. This guidance may be supplemented by the materiel developer's test plan or evaluator’s SEP and should include the following:

a. Firmly seat the test item and record the soil type.

b. Measure and record the meteorological data, as required in paragraph 4.2.9.2, on an hourly basis throughout the test period.

Note:Commence measurements just prior to the start of the test firing. Take measurements at ground level at the location of the test item and at the anticipated point of impact. Take aloft data at intervals up to and including the maximum ordinate of the round to be fired.

c. Fire at least ten minimum charge rounds with the test item at zero traverse and minimum elevation.

Note: Return the test item to its pre-firing position after each round is fired.

d. Repeat step in paragraph 4.2.9.1c for each charge appropriate for the test item.

e. Repeat steps in paragraphs 4.2.9.1c and 4.2.9.1d with the test item at specified elevations.

4.2.9.2 Data required.

a. On an hourly basis throughout the test period:

(1) Ambient temperature.

(2) Relative humidity.

(3) Atmospheric pressure.

(4) Wind speed and direction.

b. For each round fired:

(1) Muzzle velocity as described in ITOP 4-2-805.

(2) Time-of-flight as described in ITOP 4-2-805.

(3) Changes in elevation, if applicable.

(4) Changes in traverse, if applicable.

(5) Distance and direction the baseplate moved, if applicable.

c. Horizontal range and deflection of the impact of each fired round.

d. Maximum range recorded during firing at maximum service charge and minimum elevation.

e. Minimum range recorded during firing at charge zero and maximum elevation.

4.3 Adverse Conditions Tests.

4.3.1 Preparation for Tests.

a. Clean the test item and, if appropriate, apply a light coat of lubricant to the operating mechanisms.

b. Mount the test item sight and accessories.

c. Cover the muzzle with the protective muzzle cover, if provided.

d. Review handwheel torque measurements made prior to subjecting test item to each adverse environment test.

4.3.2 Extreme Temperature Tests.

4.3.2.1 Method.

a. Using an appropriate climatic-conditioning chamber, set up the weapon system (including sight unit) in the firing position and condition all components for at least 48 hours at -46 °C.

b. After conditioning, fire one maximum service charge round (conditioned to the same temperature as the mortar system) and visually examine the weapon system for damage.

c. If no damage is found, repeat the process until ten maximum service charge rounds have been fired with the system allowed to return to -46 °C between rounds.

d. Immediately after firing, conduct material soundness inspections of the weapon and components to determine the presence of cracks (TOP 3-2-807).

e. Photograph all defects.

f. Elevate and traverse the weapon through its complete range of movement, recording handwheel effort at several intervals and at any portion of movement range where effort is appreciably different.

g. Examine the sight unit for operability, including presence of moisture inside the telescope; note the operability of all sight knobs.

h. Repeat test with mortar conditioned for 48 hours at 63 °C.

4.3.2.2 Data required.

a. Interferences or malfunctions of mechanisms and moving parts induced by temperature extreme.

b. Functioning of firing mechanism (applicable if trigger or retracting firing pin components are used).

c. Positiveness of action of the firing mechanism.

d. Functioning of shock absorber assembly.

e. Shock absorber's resistance to cracking at low temperatures.

f. Handwheel effort to elevate and traverse the weapon.

g. Material soundness test results.

h. Operability of sight unit.

4.3.3 Sand-and-Dust Test.

4.3.3.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to the blowing-dust conditions specified in MIL-STD-810G, Method 510.3.

c. After exposure, remove loose dust (sand) by shaking the test item, blowing on it, or wiping it with the bare hands. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Check visibility through the sight, and note presence of trapped dust.

e. Elevate and traverse the weapon through its complete range of movement, recording handwheel effort at several intervals and at any portion of movement range where effort is appreciably different.

f. Note presence and amount of any trapped dust (sand) in cannon bore.

g. Thoroughly clean weapon system and then repeat above procedures, exposing the weapon to the blowing-sand test of MIL-STD-810G, Method 510.3.

h. Fire one maximum service charge round (conditioned at 21 ^{o}C) and visually examine the weapon system for damage.

i. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

j. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.3.2 Data required.

a. Presence of dust in sight.

b. Operability of the trigger-fire mechanism (if applicable) by firing in the trigger-fire position and then in the drop-fire position.

c. Ease of trigger-fire operation, if applicable.

d. Handwheel effort to elevate and traverse the weapon.

e. Amount of dust in cannon bore.

4.3.4 Icing Test.

4.3.4.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item and its components to the freezing-rain test as described in TOP 2-2-815[17].

c. After exposure:

(1) Check visibility through the sight, and note presence of trapped moisture within the sight and for ice in the bore or around firing pin.

(2) Elevate and traverse the weapon through its complete range of movement, recording handwheel effort at several intervals and at any portion of movement range where effort is appreciably different.

(3) Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

(4) If test center does not allow firing from icing facility/site, use an inert round with inert propelling charge and simulated initiator to verify that standard/proposed procedures adequately clear cannon bore of material that would interfere with rounds sliding down the barrel or affecting firing pin/initiator interface: otherwise, continue with steps in paragraph 4.3.4.1a(5) through 4.3.4.1a(7) below.

(5) Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

(6) If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

(7) Immediately after firing, **conduct materiel soundness inspections** of the weapon and components to determine the presence of cracks.

4.3.4.2 Data required.

a. Amount of ice needed to be removed in order to expose the firing pin.

b. Handwheel effort to elevate and traverse the weapon.

c. Operability of the trigger-fire mechanism by firing in the trigger-fire position and then in the drop-fire position.

d. Ease of trigger-fire operation.

e. Effectiveness of ice removal by firing.

4.3.5 Blowing-Snow Test.

4.3.5.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item and its components, in a conditioning chamber to blowing snow having crystal sizes and winds as described in Army Regulation (AR) 70-38[19] for 6 hours.

c. After exposure, remove and measure the amount of loose snow in bore. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Follow procedures as described in paragraph 4.3.4.1c above.

4.3.5.2 Data required.

As shown in paragraph 4.3.4.2.

4.3.6 Mud Test.

4.3.6.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to mud consisting of ten parts red clay, two parts clean river sand, and enough water to permit the item to sink of its own weight.

c. After exposure, remove loose mud with bare hands. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

e. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

f. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

g. Follow procedures as described in paragraph 4.3.4.1c, examining the sights for mud.

4.3.6.2 Data required.

As specified in paragraph 4.3.4.2.

4.3.7 Rain Test.

4.3.7.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to the rain conditions described in MIL-STD-810G, Method 506.3.

c. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

d. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

e. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

f. After exposure, examine sights for moisture and evaluate the effects on the moving parts of the mortar. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

4.3.7.2 Data required.

a. As specified in TOP 2-2-815 and MIL-STD-810G.

b. Amount of water in sights.

c. Amount of water in cannon bore.

d. Handwheel effort to elevate and traverse the weapon.

4.3.8 Humidity Test.

4.3.8.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to the applicable conditions as described in MIL-STD-810G, Method 507.3.

c. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

d. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

e. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

f. After exposure, examine sights for moisture, check for corrosion, and evaluate effects on the moving parts of the mortar. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

4.3.8.2 Data required.

a. As specified in MIL-STD-810G.

b. As specified in paragraphs 4.3.7.2b through 4.3.7.2d.

4.3.9 Solar Radiation Test.

4.3.9.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to five diurnal cycles of the hot-dry climate as described in ITOP 4-2-826[19].

c. After exposure, examine optical and moving parts for damage.

d. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

e. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

f. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.9.2 Data required.

Record damage to optical and moving parts, including handwheel effort to elevate and traverse the weapon.

4.3.10 Salt-Fog Test.

4.3.10.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to salt-fog conditions described in MIL-STD-810G, Method 509.3 for 48 hours.

c. After exposure, examine the sights for moisture, check for corrosion, and check operability of all parts. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

e. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

f. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.10.2 Data required.

a. Amount of moisture trapped within the sight.

b. Amount of corrosion.

c. Handwheel effort to elevate and traverse weapon.

4.3.11 Water-Immersion Test.

4.3.11.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item or components to the water-immersion test described in MIL-STD-810G, Method 512.3.

c. After exposure, examine the sights for moisture and check the operability of all parts. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

e. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

f. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.11.2 Data required.

As specified in paragraphs 4.3.7.2b through 4.3.7.2d.

4.3.12 Fungus Test.

4.3.12.1 Method.

a. Prepare the test item as described in paragraph 4.3.1. Cover the muzzle with the protective muzzle cover, if provided.

b. Expose the test item to the conditions described in MIL-STD-810G, Method 508.4.

c. After exposure, examine all components for moisture, fungus, and corrosion. Perform cleaning and lubrication as described in the Field Manual or instructions/equipment provided by the Developer.

d. Fire one maximum service charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

e. If no damage is found **repeat the process until five maximum service charge rounds have been fired** from the weapon.

f. Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.12.2 Data required.

a. Presence of moisture, fungus and corrosion on weapon system.

b. Operability of sight unit.

c. Handwheel effort to elevate and traverse weapon.

4.4 Rough-Handling and Transportation Tests.

The mortar shall be tested under the following conditions, as required.

4.4.1 Transportation-Vibration Test.

4.4.1.1 Method.

a. Package the test item as for shipment.

b. Conduct a simulated transportation-vibration test in accordance with ITOP 1-2-601 corresponding to a distance of 800 km in a composite of wheeled vehicles and 50 km in two-wheeled trailers.

c. Examine the test item and record the presence of any breakage, bending, loosening, or other damage.

4.4.1.2 Data required.

a. Transportation-vibration data as collected in ITOP 1-2-601.

b. Results of materiel inspections as conducted above.

4.4.2 Loose-Cargo Test.

4.4.2.1 Method.

a. Using an unpackaged test item, conduct a loose-cargo test in accordance with ITOP 4-2-602, Appendix B, to simulate 240 km of loose-cargo transport over Belgian-block road.

b. Examine the test item and record the presence of any breakage, bending, loosening, or other damage.

c. When there is no obvious damage, test fire the system using five maximum service charge rounds, then examine the test item and record any evidence of damage.

d. Use appropriate (for metallic or non-metallic tube material or tube condition) NDT technique to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.4.2.2 Data required.

a. As collected in ITOP 4-2-602.

b. Results of materiel inspections as conducted above.

4.4.3 1.5-Meter Drop Test.

4.4.3.1 Method.

a. Using an unpackaged test item, conduct a 1.5-meter drop test in accordance with Appendix C of ITOP 4-2-602.

b. Examine the test item and fire as described in steps in paragraphs 4.4.2.1c and 4.4.2.1d.

4.4.3.2 Data required.

a. As collected in ITOP 1-2-601.

b. Results of materiel inspections as conducted above.

4.4.4 Air-Transportability Test.

(To be used only if there are components susceptible to damage from low atmospheric pressure and temperature.)

4.4.4.1 Method.

a. Using a packaged test item, simulate air transport at 15,200 meters in a stratosphere chamber for 3 hours, at an air temperature of -51 °C.

b. Examine the test item for damage.

4.4.4.2 Data required.

Any damage to test item.

4.4.5 Air-Drop Test.

4.4.5.1 Method.

a. Using a test item prepared for air-drop, conduct an air-drop test in accordance with the applicable sections of ITOP 7-2-509(1)[20].

b. Examine the test item and fire as described in steps in paragraphs 4.4.2.1c and 4.4.2.1d.

4.4.5.2 Data required.

a. As collected in ITOP 7-2-509(1).

b. Results of materiel inspections as conducted above.

4.4.6 Road Test.

4.4.6.1 Method.

a. For weapons transported in a trailer or transport vehicle, mount the item on the conveyance, establish trammel points and guidelines on the item and subject it to:

(1) Forty kilometers on the Belgian block course (APG).

(2) Eighty kilometers on secondary roads.

(3) One hundred sixty kilometers on paved roads.

b. During the road tests, observe for deformations, cracks, and breaks.

c. After all road tests, completely disassemble the item and check all trammel points, guidelines, and bearing surfaces to determine wear and deformation.

4.4.6.2 Data required.

As described in paragraphs 4.4.6.1b and 4.4.6.1c.

4.5 Post Firing Inspection.

4.5.1 Method.

a. Measure the bore diameter in accordance with TOP 3-2-801 and/or using appropriate technology/procedures.

b. Visually inspect the bore in accordance with ITOP 3-2-803 and/or using appropriate technology/procedures.

c. Measure the firing-pin protrusion.

d. Examine all trammel points and guidelines.

e. Examine all moving parts for evidence of wear.

Note: Some of the above inspections, in addition to being conducted at the conclusion of all testing, are conducted following an individual test phase when, in the judgment of the test officer, such inspections are warranted.

4.5.2 Data Required.

a. Bore measurement data.

b. Bore inspection comments/data.

c. Firing-pin protrusion.

d. Deformations of firing pin.

e. For trammel points and guidelines:

(1) Wear of bearing surfaces.

(2) Deformation of bearing surfaces.

4.6 Human Factors Engineering Demonstration.

4.6.1 Method.

During the conduct of all testing phases (use guidance in ITOP 1-2-601 and US Army Developmental Test Command (DTC) Pam 602-1[21]), evaluate the mortar system to determine if it meets the operational and design requirements of MIL- STD- 1472D[22] and MIL-HDBK-759[23].

4.6.2 Data Required.

a. A record of the physical characteristics of the weapon and ammunition as they affect operation.

b. Notes on the adequacy and size of knobs, handwheels, and leveling devices on the weapon and sight unit; ability to operate these knobs/devices both with and without arctic/nuclear, biological, chemical (NBC) handwear.

c. The times required to emplace the weapon and prepare to fire.

d. A notation of any features of the test mortar that are not compatible with the skills and aptitudes of military occupational specialty (MOS)-qualified Soldiers.

e. General ease of operation of the test item.

4.7 Tools and Accessories Evaluation.

4.7.1 Method.

Throughout the conduct of the test, examine all standard and special tools and accessories supplied with the test item. Use guidance in AR 700-127[24], Integrated Logistics Support.

4.1.2 Data Required.

a. Suitability of the tools and accessories.

b. Requirement for additional tools.

c. Parts that are apt to require replacement, which should be included as spare parts.

d. Whether system peculiar tools are, in fact, needed or if they can be replaced with common tools.

5. DATA REQUIRED.

The data required are listed under each method in Section 4.

6. PRESENTATION OF DATA.

a. Present data in graphic or table format, as applicable, to summarize the results of each subtest performed.

b. Document the results of all post firing/test inspections and indicate the following:

(1) Effect of firing or transportation on the test item alignment as indicated by trammel point and reference and guideline measurements.

(2) Length of firing pin protrusion.

(3) Bore diameter measurements.

c. Calculate the mean and standard deviation for the following data.

(1) Time required to prepare the weapon for firing and travel (paragraph 4.1.12).

(2) Time required to fire each round, time to reach the D-MOT, number of rounds fired, maximum rate-of-fire (paragraph 4.2.3.2).

(3) Muzzle velocity and chamber pressure (paragraph 4.2.6).

(4) Range and deflection of rounds fired (paragraph 4.2.9). Group data according to charge and elevation.

d. Present the change in weapon elevation and deflection and the distance in centimeters of baseplate movement (paragraph 4.2.7) in tabular format. Group the data according to weapon orientation, surface fired from, and use of sandbags on baseplate. Indicate whether or not the weapon was relayed after firing.

e. Report malfunctions, operating difficulties, and hazardous occurrences to the concerned technical agency as soon as practicable, using standard reporting methods such as Test Incident Reports (TIRs).

f. The safety information developed during the engineering test will be used as the basis for submitting a recommendation for Safety Release or Safety Confirmation to DTC in accordance with AR 385-10[25] Supplemented by DA PAM 385-16[26].

APPENDIX A. BACKGROUND

1. Introduction.

Weapon system safety and technical assessment are a continuous process. Initially, during early developmental tests, it is necessary to establish that the design is inherently sound. Later, it is necessary to develop formal test data to show that the weapon system is safe to use and is performing at a level which warrants continued production effort. If the item is type classified and production is initiated, it is essential to show that changes implemented to simplify production and the production process do not compromise the system's safety and performance. Finally, as product improvements are proposed for incorporation into the weapon system design, it must be shown that these improvements will result in a better system in terms of both performance and system safety.

2. Test Design Criteria.

Criteria for testing must be based primarily on the required operational capabilities, the Independent Evaluation Plan/Test Design Plan (IEP/TDP) or Independent Assessment Plan (IAP), and the test item and the procedures as outlined in this TOP. The following must also be considered:

a. Design Review. Before undertaking the tests outlined in this TOP, the test officer should perform a thorough review of all data related to the item being tested. These data can be obtained from previous related tests and/or design considerations. If the review shows that the test item conforms to a proven design and that its performance (or that of similar items) in earlier (engineering design or component) tests are favorable, then the procedures as outlined in this TOP may be undertaken. If not, the Test Plan must be expanded to provide the necessary assurance.

b. Safety Assessment Report (SAR).

(1) Submission of an SAR from the developer is required at least 60 days before the start of technical testing. The test director will review the sponsor's SAR in accordance with the Guide for the Development of Safety Assessment Report[27] and use or develop safe-operating procedure in accordance with AR 385-10 supplemented by DA PAM 385-16.

(2) It is essential that the SAR contain the following information:

(a) Complete system description.

(b) Complete sequence of system operation emphasizing the safety features.

(c) Thorough misfire procedures.

(d) System hazard analysis.

(e) Acceptable ammunition for use.

(f) Weapon upper pressure limit (UPL), permissible maximum pressure, and design pressure.

(g) Designated maximum operating temperature.

(h) Serviceability criteria for inspection.

APPENDIX B. ABBREVIATIONS

AMC	=	U.S. Army Materiel Command
AR	=	Army Regulation
ARDEC	=	U.S. Army Armament Research, Development and Engineering Center
D-MOT	=	designated/design maximum operating temperature
DTC	=	U.S. Army Developmental Test Command
DTIC	=	Defense Technical Information Center
DTP	=	Detailed Test Plan
IAP	=	Independent Assessment Plan
IEP	=	Independent Evaluation Plan
IPT	=	Integrated Product Team
ITOP	=	International Test operation Procedure
MOS	=	military occupational specialty
NATO	=	North Atlantic Treaty Organization
NBC	=	nuclear, biological, chemical
NDT	=	nondestructive test
SAR	=	Safety Assessment Report
SEP	=	System Evaluation Plan
SOP	=	Standing Operating Procedure
STANAG	=	Standardization Agreement
TB	=	Technical Bulletin
TDP	=	Test Design Plan
TIR	=	Test Incident Report
TOP	=	Test Operations Procedure
UPL	=	upper pressure limit

APPENDIX C. REFERENCES

1. TOP 4-2-504(3), Safety Testing of Mortar Ammunition, 31 October 1991.

2. ITOP 1-2-601, Laboratory Vibration Schedules, 19 February 2009.

3. ITOP 4-2-602, Rough Handling Tests, 27 September 2004.

4. ITOP 4-2-805, Projectile Velocity and Time of Flight Measurements, 20 September 2005.

5. ITOP 3-2-810, Weapon Chamber Pressure Measurements, 18 December 1985.

6. TOP 1-1-058, Temperature-Measuring Devices, 30 November 1982.

7. TOP 3-2-801, Measurement of Internal Diameters of Cannon, 27 October 1965.

8. ITOP 3-2-803, Visual Inspection of Cannon Bores, 1 October 1992.

9. TOP 3-1-003, Meteorological Data for Testing, 2 June 1981.

10. North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 4370, Environmental Testing, 19 April 2005.

11. Military Standard (MIL-STD) 810G, Environmental Test Methods and Engineering Guidelines, 31 October 2008.

12. TOP 3-2-807, Nondestructive Testing of Materials, 5 December 1985.

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